QUALITY AND MANAGEMENT

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THE EFFECT OF BATCH PREPARATION TECHNOLOGY ON ITS QUALITY

R. I. Makarov,[1] E. R. Khorosheva,[1] K. Yu. Subbotin,[1] V. V. Efremenkov,[1] and A. V. Molodkin[1]

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The quality of batch-preparation process is estimated by determining the properties of sheet glass produced. Statistical research methods are used.

The important parameters of the batch preparation technology are the steadiness and precision of the process [1]. The precision and steadiness of the process of batch preparation can be estimated based on the properties of its finished product, namely, clear sheet glass. Let us analyze the effect of the quality of the batch on glass density and optical distortion visible in transmitted light and measured by the Zebra method.

To estimate the precision and steadiness of the technological process of batch preparation, an analysis of the variation in the density and optical distortion of the produced glass (Figs. 1 and 2) was performed at the Borskii Glass Works.

The plot shows a linear trend indicating the deviation of density and optical distortion toward their increase. The reasons for this instability can be common or different. To identify these reasons we have constructed a dispersion field plot in the "optical distortions – glass density" coordinates (Fig. 3). A significant correlation between the analyzed properties of glass produced (correlation coefficient $R^2 = 0.37$) corroborates the presence of common destabilizing factors.

To identify factors affecting quality, we analyzed the quality parameters of a batch for glass melting. The quality of a finished batch in production is checked twice per shift by a lab technician of the central factory laboratory by taking a sample from each mixer. The monitored parameters are the batch temperature (35 – 55°C), moisture (4.5 ± 0.5%), and deviation of the batch components from a prescribed composition (not more than ± 1.0%). The quality of the batch supplied for glass melting in the course of the year 2003 is characterized by the statistical data in Table 1.

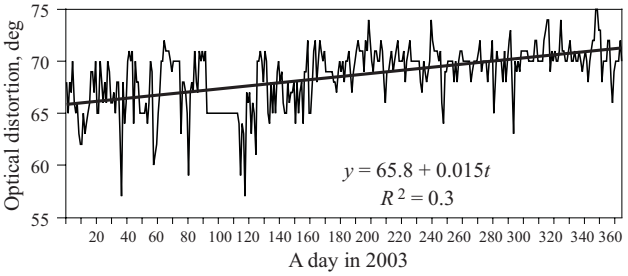

Fig. 2. Optical distortions visible in transmitted light and measured by the Zebra method.

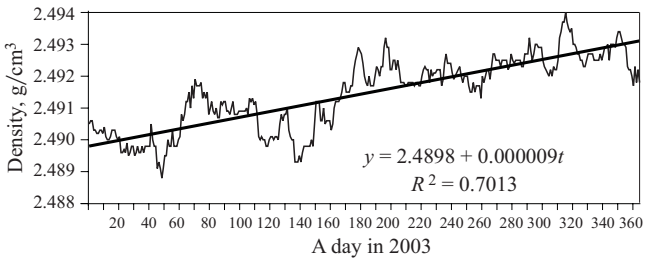

Fig. 1. Variation in density of glass produced during a day (24 h) t in 2003.

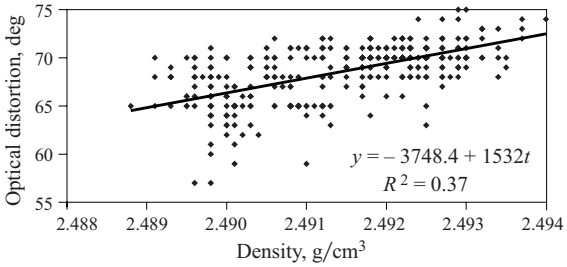

Fig. 3. Dependence of optical distortion in glass measured by the Zebra method on density.

[1] Vladimir State University, Vladimir, Russia; Stromizmeritel' Joint-Stock Company, Nizhny Novgorod, Russia; Borskii Glass Works, Bor, Russia.

TABLE 1

Parameter	Batch in 2003			Correlation coefficient of	
	average values	standard deviation	variation coefficient, %	glass density	optical distortions
Weight content %:					
insoluble residue	61.03	0.35	0.58	– 0.61	– 0.43
soda	17.75	0.27	1.53	0.25	0.17
sulfates	0.77	0.21	27.10	0.07*	0.03*
carbonates	20.47	0.02	0.12	0.75	0.52
Moisture, %	4.43	0.18	4.00	0.005*	0.01*
Temperature, °C	49.14	2.85	5.80	– 0.55	– 0.41

* Correlation coefficients are insignificant.

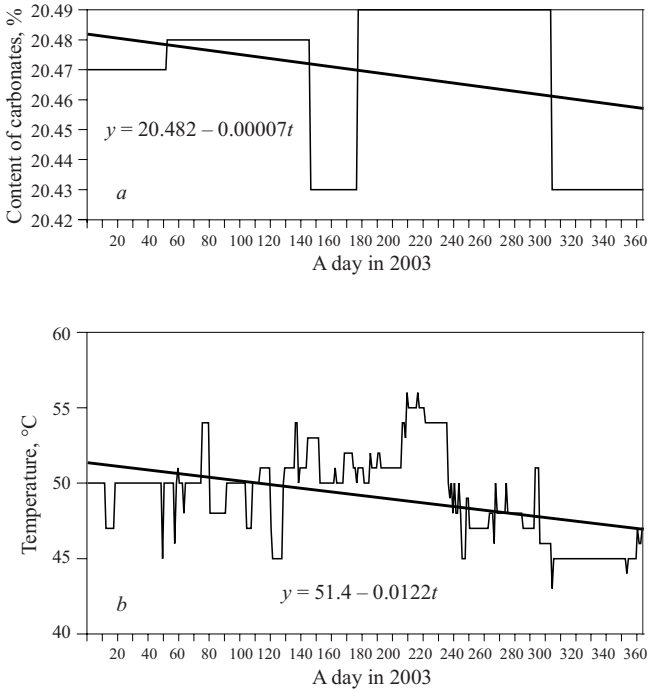

Fig. 4. Variation in the content of carbonates in the batch (*a*) and its temperature (*b*).

The most perceptible variations are observed in such parameters of the batch quality as the content of sulfates, the temperature, and the moisture of the batch. To clarify the factors that have the maximum effect on glass properties, a correlation analysis of the dependence of its properties of the batch quality parameters was carried out. The correlation coefficient matrix is shown in Table 1.

It can be seen that a variation in sulfate content (27.1%) and batch moisture (4.0%) does not have a perceptible effect on the properties of glass produced. To identify the quantitative dependence of density D and optical distortions in glass Z on the batch quality parameters, regression analysis was carried out, which yielded the following equation:

$$D = 1233.94 - 120.382C_c + 2.942(C_c)^2 - 0.0001083\theta_b; \quad (1)^2$$

$$Z = 2.03 \times 10^6 - 198{,}521C_c + 4851.47(C_c)^2 - 0.121\theta_b, \quad (2)^3$$

where C_c is the content of carbonates in the batch, %; θ_b is the batch temperature, °C.

The accuracy of Eq. (1) is high and it can be used to determine corrective actions in the technological process of batch preparation for the purpose of stabilizing the properties of the glass produced. The sensitivity of density to the variation in the content of carbonates and batch temperature is estimated using particular elasticity coefficients, which are equal to 0.52 and – 0.0021, respectively. These coefficients indicate by how many percent the glass density changes on the average, if the carbonate content and batch temperature change by 1%. When the carbonate content in the batch changes by the standard deviation value equal to 0.024%, the glass density changes significantly: by 0.0015 g/cm^3. The variation in the batch temperature has a smaller effect. By changing the temperature by the standard deviation value of 2.85°C, the density changes by 0.0003 g/cm^3. The revealed dependence requires a more stable content of carbonates in the batch prepared for melting.

One of the factors causing a drift in the density and optical distortion of glass is the presence of a trend in the carbonate content and the temperature of the batch supplied to glass melting (Fig. 4). A trend to decreasing the carbonate content and the batch temperature leads to an increasing density of glass and a decrease in the optical distortion in the glass ribbon. The calculation indicates that the glass density trend to an extent of 60 – 65% is caused by the trends of the carbonate content in the batch and its temperature.

The performed study suggests the possibility of controlling the technological process of batch preparation based on the analysis of statistic data on the properties of glass produced. The improvement of the batch preparation process calls for stricter tolerances on deviations in carbonate content and stabilization of the batch temperature.

REFERENCES

1. V. K. Fedyukin, *Process Quality Management* [in Russian], Piter, St. Petersburg (2004).

[2] The accuracy of the regression equation is characterized by the residual dispersion value of 35.88×10^{-8} (g/cm^3)^2 and multiple correlation coefficient $R^2 = 0.73$.

[3] The accuracy of the regression equation is characterized by the residual dispersion value (7.4 deg)^2 and multiple correlation coefficient $R^2 = 0.31$.